Open Ocean Aquaculture – a Venue for Cooperative Research Between the United States and Japan

Charles E. Helsley
Sea Grant College Program
University of Hawaii at Manoa
2525 Correa Road
Honolulu, Hawaii 96822
USA

During the past decade, aquaculture in the United States has begun to assume a more significant role both in U.S. policy and in the U.S. economy. In 1999 the U.S. Department of Commerce (DOC) enunciated a policy to encourage aquaculture development in the United States. This plan envisages the growth of the aquaculture industry from the current value of $900 million to $5 billion by 2025. It will involve a five-fold production increase in order to reduce the seafood import deficit and stabilize world seafood supplies. Success of the plan will depend upon rapid removal of administrative and scientific impediments.

At the time the plan was promulgated, aquaculture in the U.S. was primarily a land-based activity utilizing fresh water ponds and tanks constructed along or near rivers. Catfish production was ten-fold that of other species and grew more than 40% during the past decade. However, during the same decade several other species declined, especially those grown in estuaries, such as the American Oyster, or in flood plains along rivers, such as crawfish. These declines probably resulted from price competition, decreasing water quality, habitat destruction, and land use changes.

The expansion of marine organism production on near-shore land will likely be limited, as it is already in high demand and expensive. Freshwater expansion is also likely to decrease as readily accessible areas are already being utilized. Near-shore protected waters are generally areas of substantial use conflict. They are currently already at or near carrying capacity due to the abundant sources of nutrients that can be drawn from nearby upland areas.

In the past five years, there have been several attempts to make greater use of our near-shore marine waters, particularly for salmon, clams, oysters and shrimp. As a result of changes in national policy, marine aquaculture, both near-shore and offshore, is poised for significant expansion during the next decade. But in near-shore waters, this expansion faces significant opposition primarily by those that believe these waters are common areas and already used to capacity.

Background

The geography of the coastal U.S. can be subdivided into four general classes: sandy beaches, coastal estuaries, glaciated areas with fjords, and rugged rocky coasts generally with few embayments. Each of these areas is heavily urbanized since half of the U.S. population lives within 200 km of the coast.

Urbanization brings with it the problems of runoff from paved areas, discharge of industrial and human wastes and a general diminution of water quality. Combining urban discharge with agricultural runoff substantially increases the possibility of nutrient enrichment of coastal waters. This problem now exists in several of the largest estuarine systems in the United States. The aquaculture of species other than filter feeders (clams, oysters, menhaden) or detritivores (mullet, shrimp) is unlikely to be encouraged in these areas.

Sandy beach coasts are generally areas of high wave activity, especially during storms. Moreover, the water tends to be relatively shallow for long distances offshore and in many areas in the Gulf of Mexico and the Atlantic seaboard one must go 50 to 100 k from shore before waters of 20 m depth is reached. Thus, aquaculture in these areas is restricted to the growing of various benthic organisms.

Glaciated areas have many fjords developed in deeply embayed coastlines. This type of coastline is present in New England from New York City to the Canadian border, the Puget Sound area of Washington State, and in Alaska. Most of the marine aquaculture effort has been placed in these areas and appear at first glance to be ideal for near-shore, sheltered water development. However, there are many conflicting demands on these waters, most notably the 'not in my front yard' syndrome exercised by wealthy landowners who value the pristine views of the bay. Several political jurisdictions, especially in Alaska, greatly restrict or prohibit all forms of net pen aquaculture.

The rocky and mountainous coasts of the western U.S. are generally highly exposed with few sheltered areas and even fewer port facilities. These appear to be unlikely targets for near-shore marine aquaculture development in the near future.

But there are sites in the offshore in all regions that may be suitable areas for aquaculture. Of particular interest are those locations where the water depth is deep enough to assure circulation but shallow enough to enable anchoring to take place.

From a geographical perspective it is unlikely that finfish aquaculture will expand very much in near-shore waters for these are areas where conflict is greatest and public concern for water quality is likely to become an insurmountable obstacle. Substantial expansion may be possible in areas further offshore, but even here, it will require acceptance by consumers and the rapid removal of administrative impediments currently present in the permitting process. It also will require the development and implementation of sustainable new production technologies.

The Challenges

Although offshore areas appear attractive, many challenges must be overcome to make use of these areas. These challenges fall into at least four classes: (1) Social – public acceptance, jurisdiction, and permitting; (2) Technological – development of cages, culture and feeding systems, harvesting systems, etc., (3) Biological – development of new species, use of indigenous species, adequacy of food supply, management of disease and (4) Managerial – issuance and monitoring of leases, requirements for routine monitoring of effluents, and the development of the best management approach to husbandry practices. In addition, one must consider a series of infrastructure issues (ports, hatchery, and processing facilities) and marketing issues. Clearly, there are enough challenges to go around.

From the social perspective, it is likely that environmental critics will challenge the development of offshore areas on several grounds. Questions that might be asked are: What happens to the waste products? Will water quality be impacted? Are blooms of phytoplankton likely? Will they engender harmful algal blooms? Will the accidental release of fish from offshore fish farms endanger native stocks? What are we going to feed the fish? Will we endanger other areas in doing so? Will the farms be harbingers of disease? What technologies are to be used to ameliorate these concerns?

One would think that experiences from elsewhere in the world could offer solutions to these public concerns. But unfortunately most current literature focuses on the failures rather than the successes of these programs. Many more case histories of success are needed with adequate documentation of the environmental impacts, so that factual material is available to counter the critics. Needed most importantly is evidence of benign or beneficial interactions with the environment rather than reports that focus solely on the devastation of accidental releases, eutrophication due to over feeding or overproduction in a confined body of water.

The technology of growing fish in cages should be shifted from a systems point of view to an emphasis on strengthening the weakest links in the system. Until recently, offshore aquaculture was impractical because the cages would not stand the stress of the high-energy offshore environment. With better design and use of stronger and better-engineered materials this constraint has been largely removed. The questions now become: Can the fish stand this high-energy environment? Can the offshore environment accept this added load on its carrying capacity? Can we develop efficient means of feeding and harvesting fish in these higher energy environments? Can we make use of a systems approach for integrating species, cages, hatcheries, harvesting, and waste recycling? What are the economics involved in a move to far-offshore environments?

Understanding the reproductive biology of indigenous species is an essential component of aquaculture development in much of the U.S. since the use of non-indigenous stocks is likely to meet with considerable opposition. Moreover, the biological interaction between the cultured stock and the wild stock needs to be understood. We need much more understanding of the use of polyculture in waste management and disease control as well.

Management strategies in the U.S. are virtually non-existent and all decisions are made on a case-by-case basis. We need to develop a more uniform management approach in which an agency takes the lead role rather than all agencies asserting their right to control portions of the development. Aquaculture must be understood as an agricultural activity in which certain changes are permitted and expected. Moreover, we need to carefully assess the carrying capacity of offshore waters and to understand the role of waste products in this environment where circulation is high and concentration of nutrients and particulates is low. Clearly, “too much” is “too much” in any environment, but we currently have no idea how to define “too much” in any qualitative or quantitative way.

<u>Research Needs</u>

To assist in meeting the long-term Department of Commerce objectives, a number of activities need to be taken on a coordinated basis. Among the many possibilities that could be addressed to expedite the growth of an offshore aquaculture activity, more than a dozen major areas of research immediately come to mind. These include:

- Permitting The permitting process is cumbersome and considerable agency overlap exists. This makes it “expensive” to get started. The process needs to be clarified and streamlined, perhaps by simply making it a parallel process rather than a serial one. Redundancy and overlap in jurisdiction between agencies also needs to be minimized.

- Environmental Impact – The interaction of an open ocean cage culture farm with multiple cages has not been studied adequately and considerable uncertainty exists as to the short term and long term environmental effects of one or more cages or farms in the oligotrophic waters of the tropics. As the first few farms develop, they must be carefully observed to determine their interaction with the ecosystem external to the cage including nearby coral reefs. There is no reason to expect adverse interactions at the levels of discharge expected but this needs to be verified.

- Environmental Monitoring – Current methods of monitoring of nutrients in oligotophic waters are both time consuming and expensive. Methods should be found to monitor appropriate compounds, organisms, or proxies on an instrumental probe or remote-sensing basis rather than to collect individual water samples for future laboratory analysis.

- Nutrition and Animal Husbandry – Only a few tropical species have life cycles that are well enough understood to permit reliable culture. Even though we can culture many of these to marketable size, we do not understand the nutritional needs or animal behavior and husbandry issues well enough to reliably culture them in an economic fashion.

- Hatchery Development – Offshore farms must be able to produce large numbers of fingerlings of uniform size. Currently few hatcheries are capable of this. Many are needed in order to minimize risk to all farmers. Increased understanding of hatchery technology and methodology is also highly desirable. The effect of culture density on juvenile size also needs to be more fully understood.

- Diversity of Brood-Stocks – Multiple sites need to begin to maintain brood-stock of all cultured species in any given area. These stocks need to be maintained with a genetic makeup that is equivalent to that of the wild stock (just in case a cage breaks up and releases a large number of fish).

- Hatchery Technologies- Hatchery technologies are often developed at a laboratory scale. But the methods developed in the laboratory need to be field tested to determine their efficiency and/or profitability under “real world” conditions.

- Cultured Species – The number of species under culture must be increased. A diversity of species is needed to avoid flooding the market with any one species. Moreover, some species may grow faster than others and thus appear ideal, but the market demands variety and thus many species are likely to be needed to sustain a viable open ocean aquaculture operation.

- Life history – Life history investigations on many invertebrates and vertebrates used in the marine ornamental trade need to be studied in a systematic approach to develop culture technologies and/or management strategies for sustainable harvest.

- Market Development – Marketing is one of the most critical components in the economic success of offshore aquaculture project. Reliable demand driven markets need to be developed for each species under culture.

- Disease Diagnosis and Prevention – Disease diagnosis and prevention is generally done in hindsight. In most aquaculture operations, it is only addressed once disease has become a major problem. In most cultured seafood activities disease appears as the operation expands to higher densities in the same limited area. Although this is most recognizable in shrimp, it is also present in salmon and can be expected to become an issue for all cultured species. We need to understand disease pathogens before, not after, they become the “make or break” economic topic.

- Feed and Harvesting Technology – Feed and harvesting technology in large part has been developed for surface cages in sheltered water environments. Open ocean culture of fish will require changes in these established practices for the operation will of necessity have to be undertaken in more remote locations and will regularly involve working in adverse and even hazardous conditions. Many operations will require long hours at sea and will often require divers on a regular or routine basis. Automation of feed delivery systems and harvest systems is needed to minimize these costs and hazards.

- Policy and Regulation Issues – Policy and regulations governing the discharge from confined farm animal facilities in the U.S. were developed from a land culture perspective. These policies and rules have been transferred to the ocean realm without considering the change in the environment or natural living conditions of the species under culture. The rules for confined culture of farmed animals on land does not readily adapt itself to offshore conditions where prodigious quantities of water flow through the facility and the water itself is the medium in which the organism is being grown. The standard policies and regulations need to be changed to accommodate this new industry.

- Education – Public education is essential to the development of a friendly consumer and accepting public. Currently, educational materials for marine aquaculture are lacking and there is need for both the development of educational material for the general public and for those that intend to make this topic their profession. Support for specialists to assist in the resolution of problems that entrepreneurs in this field may encounter is also needed.

<u>Current Sea Grant Sponsored Research Activities</u>

As part of the National Marine Aquaculture Initiative program, Sea Grant programs throughout the U.S. are initiating new research programs focused on marine and offshore aquaculture. Many new species are currently being studied. These include: halibut, haddock, and cod at the University of New Hampshire; black sea bass at the University of South Carolina; mutton snapper at University of Miami and the University of North Carolina; cobia at the Universities of Virginia, South Carolina, Mississippi, and Texas; yellow tail snapper at the University of Texas; sable fish (a cod) and cardinal rockfish at the NMFS Mansfield Laboratory; corvina at the University of California; and bay scallops at the NMFS Milford Laboratory and the University of South Florida.

At many institutions additional marine species are under culture using other sources of funding. In Hawaii these include amberjack, opakapaka (a deep-water snapper), Gulf of Mexico red snapper, moi (pacific threadfin), mahimahi, striped mullet, milkfish, kumu (a goatfish) and a number of marine ornamentals. There are environmental studies on an active offshore farm at the University of Hawaii, animal husbandry and nutrition studies at the Oceanic Institute, and studies of cage design and anchor systems at the University of New Hampshire and MIT. MIT is also developing designs for automated feeders and the culture of flounder in closed circulation systems at the University of Connecticut and at North Carolina State University.

The Role of the UJNR Aquaculture Panel

Given the expected developments in research and commercial farms throughout the U.S. over the next few years, it is imperative to address the issues summarized above as soon as possible. Many of these are topics have been the subject of cooperative research and information exchange within UJNR in the past and remain issues for future cooperative efforts. Hatchery technology advanced culture technologies, culture of new species, identification and control of disease organisms are obvious examples. New areas of study might include development of cages and husbandry technology for rough water environments, identification of alternative food sources, understanding of nutrition requirements, definition of carrying capacity of coastal and offshore waters, development and application of environmental monitoring technology, consideration of regulatory and policy issues, and ocean ranching. Each of these topics would benefit from multidisciplinary approaches to science and the exchange of ideas from diverse experience bases. The broad topics mentioned would provide opportunities for scientific exchange particularly between young scientists with ideas and technologies at the borders of the "tried and true" conventional methodologies. All of these areas appear eminently suitable for future UJNR efforts

Cooperation between researchers in the U.S. and Japan is highly desirable to accomplish these goals. The cooperative international scientific information exchange program fostered by the UJNR Aquaculture program has enabled many U.S. scientists to become more aware of Japan's extensive experience and research base in marine aquaculture. The development of an active marine aquaculture research program in the U.S. presents an opportunity to expand upon those ties and to provide information useful to both countries as we attempt to make more utilization of the sea. Possible areas of further scientific research and information exchange include: (1) establishment of culture protocol for additional species, such as cold water, deep water, tropical and subtropical species, (2) establishing guidelines for the assessment of carrying capacity of coastal and offshore waters; (3) identification of additional sources of high protein fish food and development of additional additives and nutrition enhancers and (4) the development of technologies that would assist in the growth of the aquaculture industry in more exposed locations.

Conclusion

The research and exchange of ideas related to the extension of current aquacultural activities into more exposed and high-energy environments, generally referred to as Open Ocean Aquaculture, appears to be a fruitful area for future UJNR activities. The breadth of topics is appropriate, the need is present, and the growing commitments within the U.S. all suggest that this would be an appropriate theme for future exchanges.